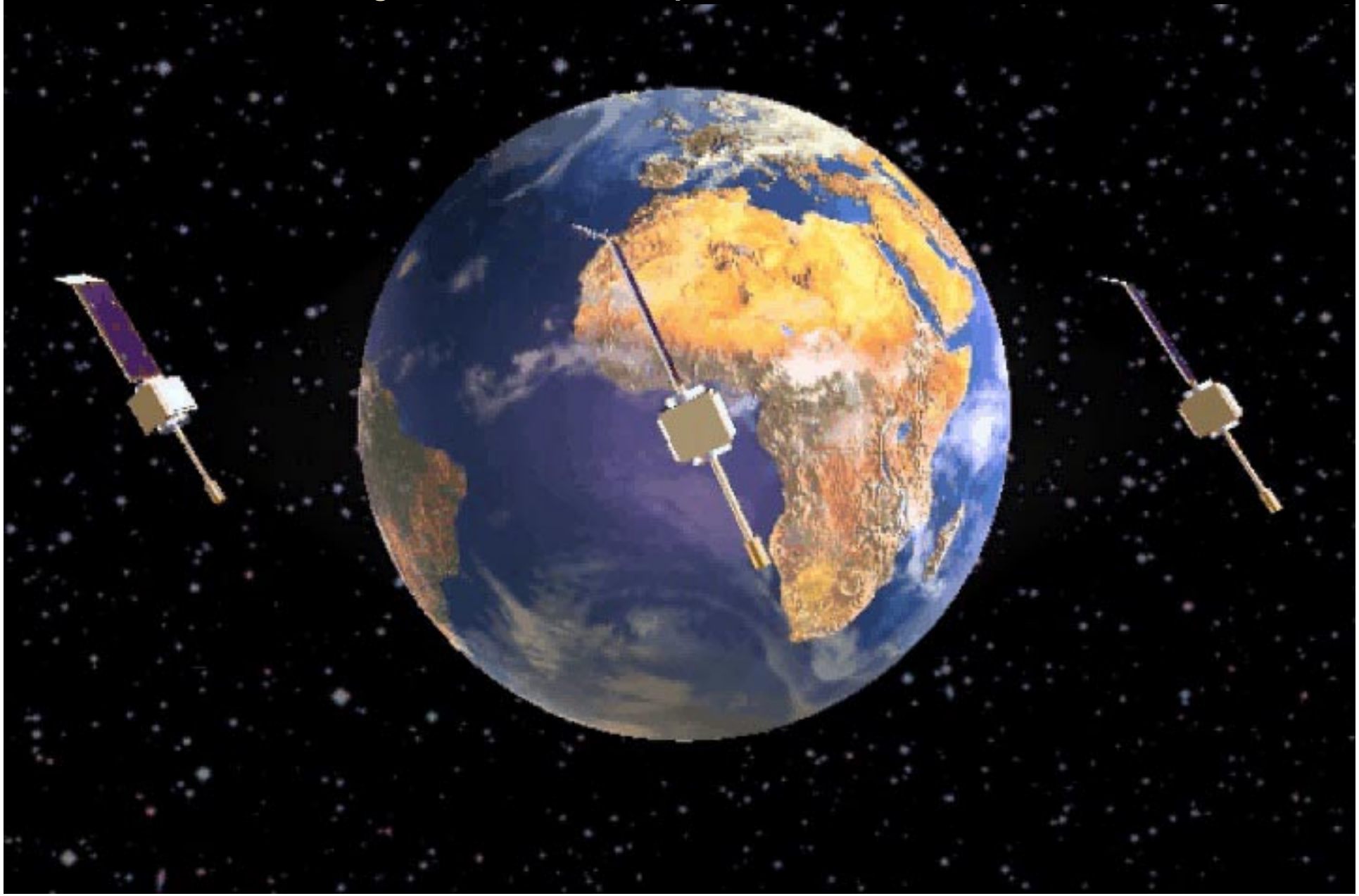
Geosynchronous Imaging Fourier Transform Spectrometer -Indian Ocean METOC Imager (GIFTS-IOMI)

Pioneering Geo-Science and Operations for the New Millennium



GIFTS-IOMI Mission

Briefing to ESE Technology Strategy Team

November 29, 2001

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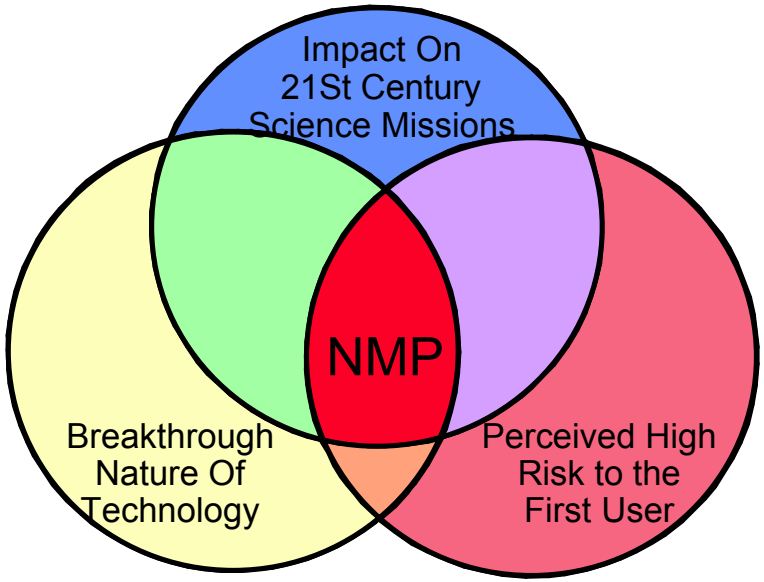
New Millennium Program

Flight Validation of Breakthrough Technologies to Benefit Future Earth Science Missions



Breakthrough technologies

- Enable new capabilities to meet Earth Science needs
- Reduce costs of future missions

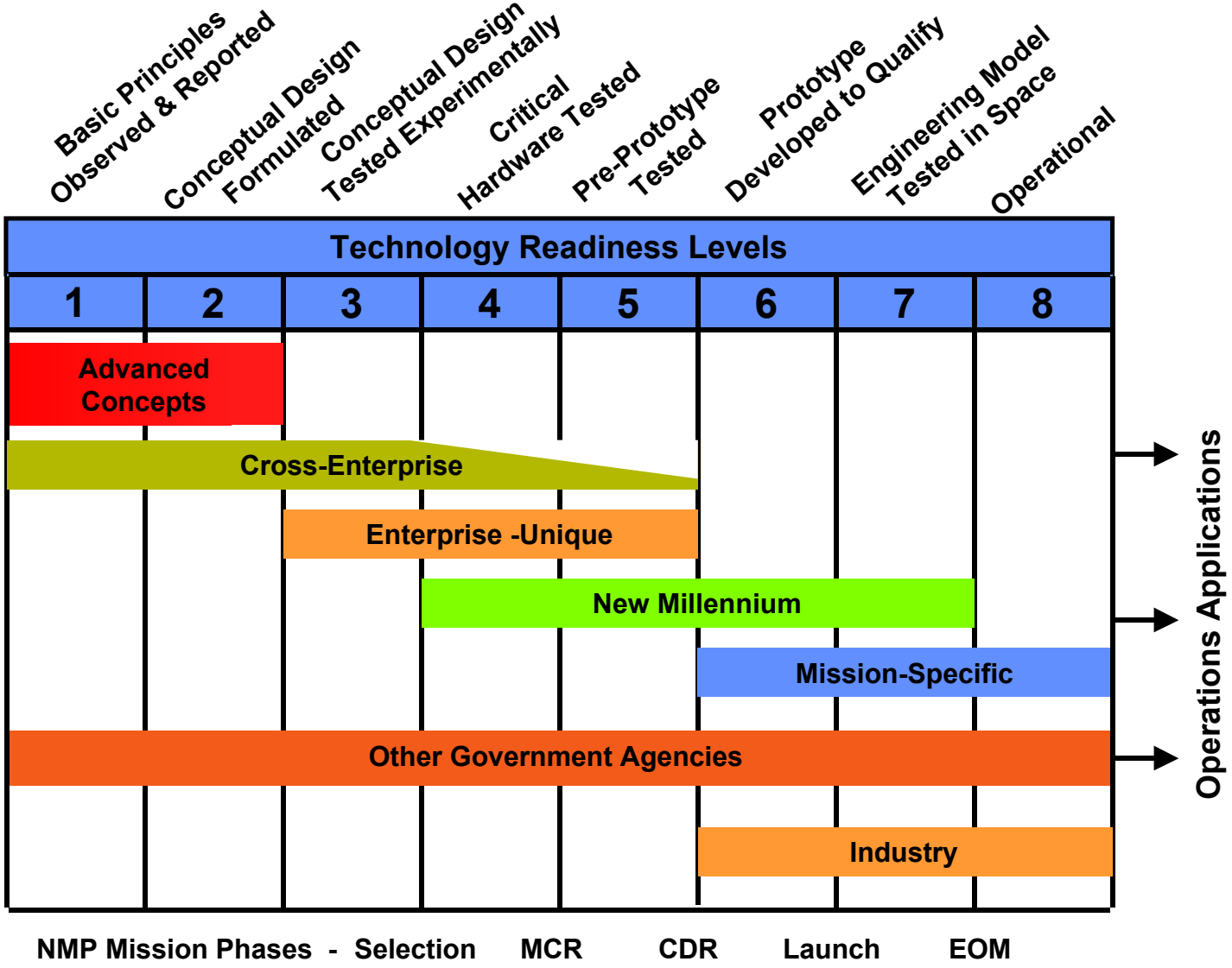
Flight validation

- Mitigates risks to first users
- Enables rapid technology infusion into future missions

NMP Program Objectives

- Both the Space Science and Earth Science Enterprises utilize the NMP as a primary entity to flight validate key emerging technologies to achieve NASA's strategic objectives with exciting 21st century earth and space science missions. To fulfill this critical role, the NMP will have three primary objectives:
  - Identify and select technologies for flight validations that optimize the benefits to the Space and Earth Science programs;
  - Develop and implement effective validation flight projects as appropriate testbeds to mitigate the risks for using the selected technologies; and
  - Facilitate the infusion of the validated technologies into future science mission opportunities.

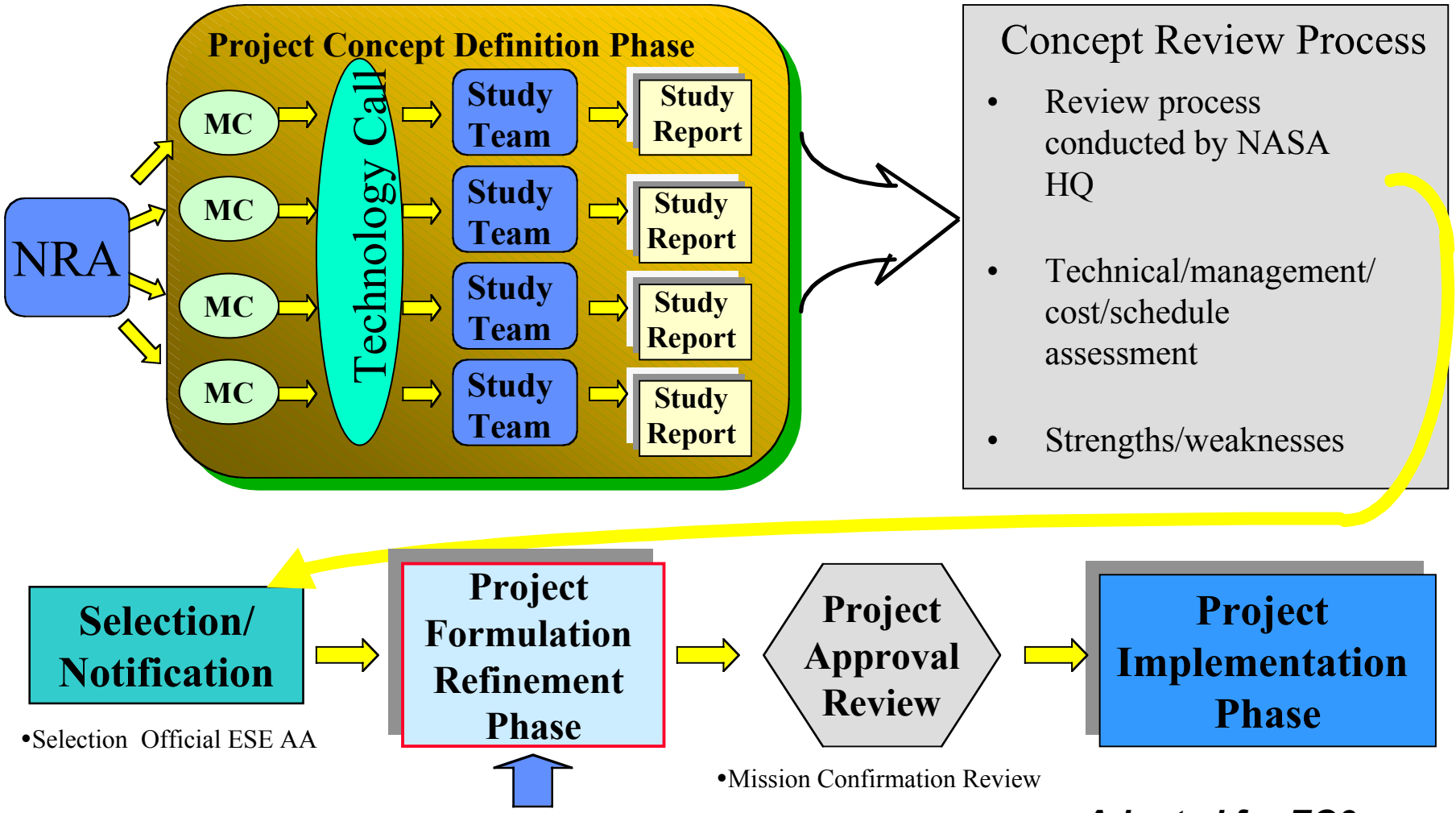
Role of NMP in Technology Development



New Millennium Program Project Formulation

Code Y Process

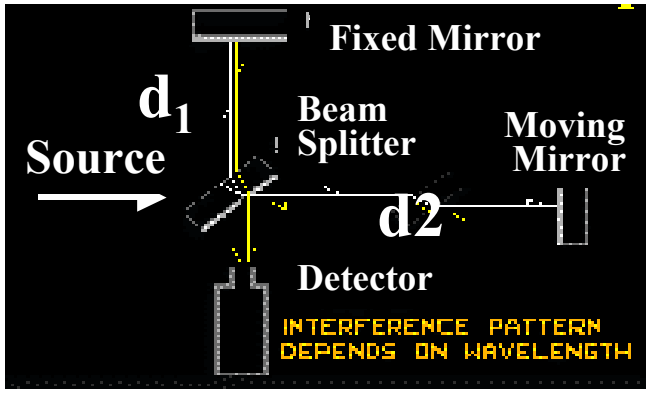
- **Focused on measurement concepts**



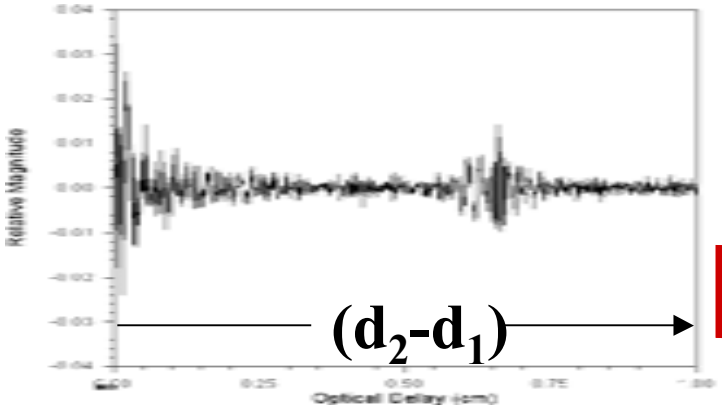
• ***Adopted for EO3***

High Spectral Resolution Imagery

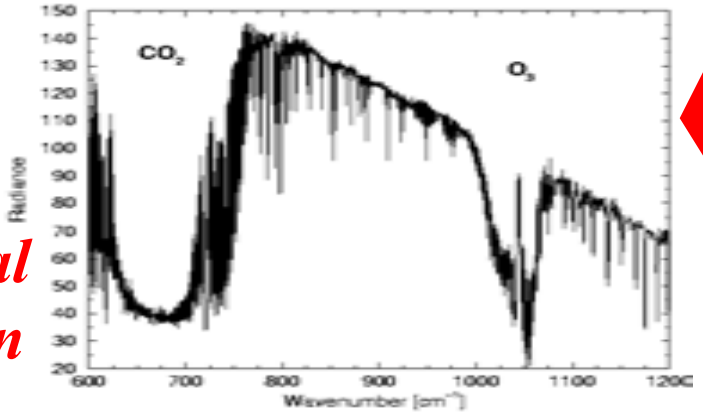
Michelson Interferometer (FTS)



Interferogram

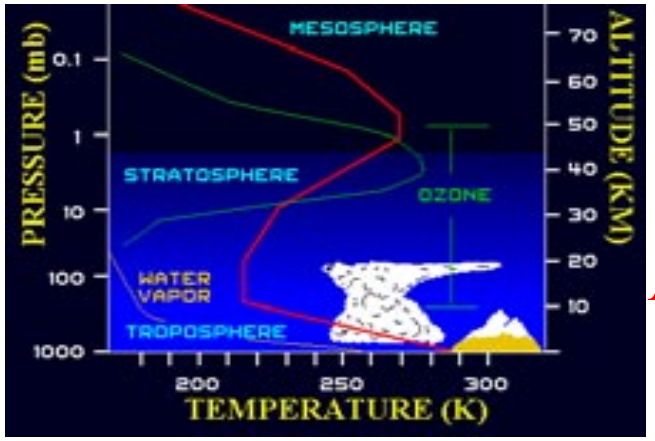


Fourier Transformation



Radiance Spectrum

Numerical Inversion

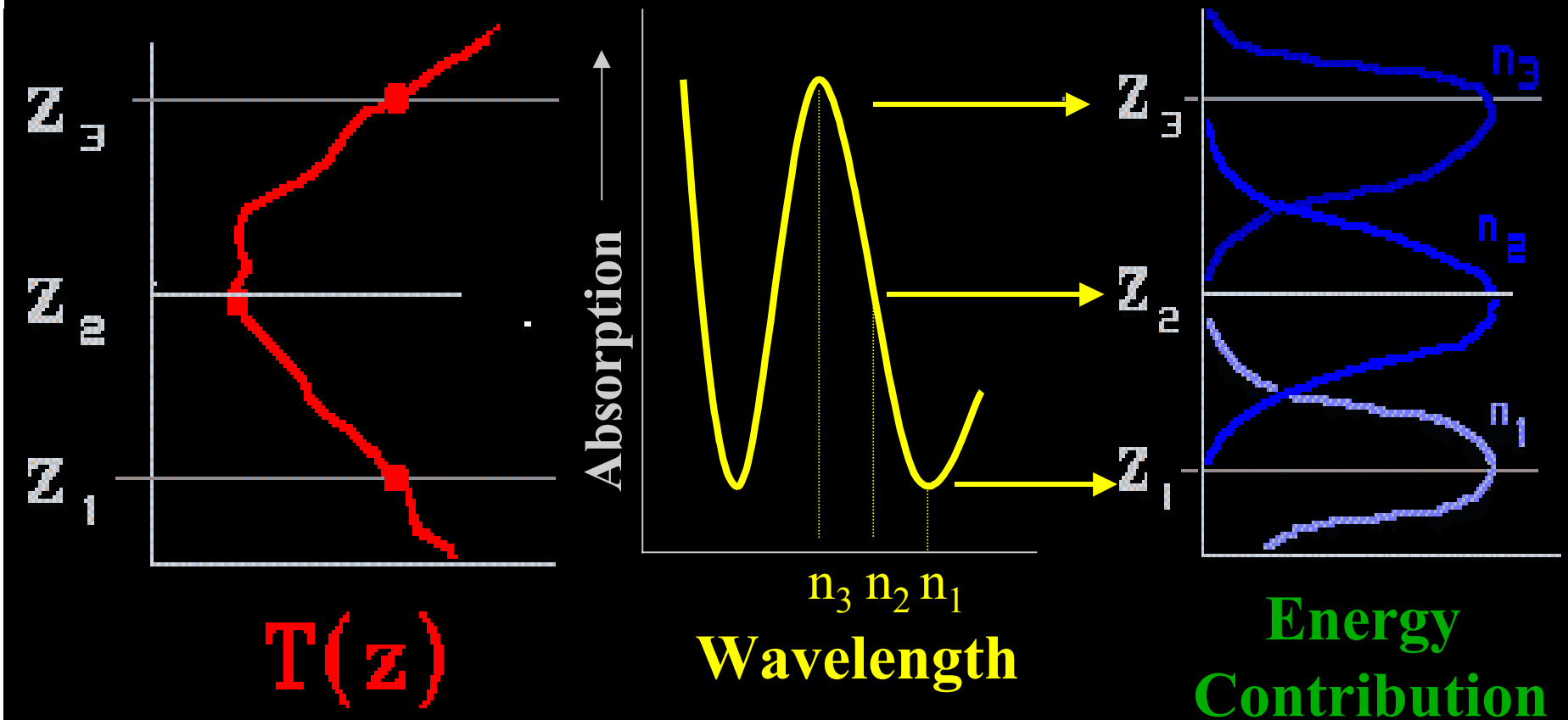


Vertical Sounding

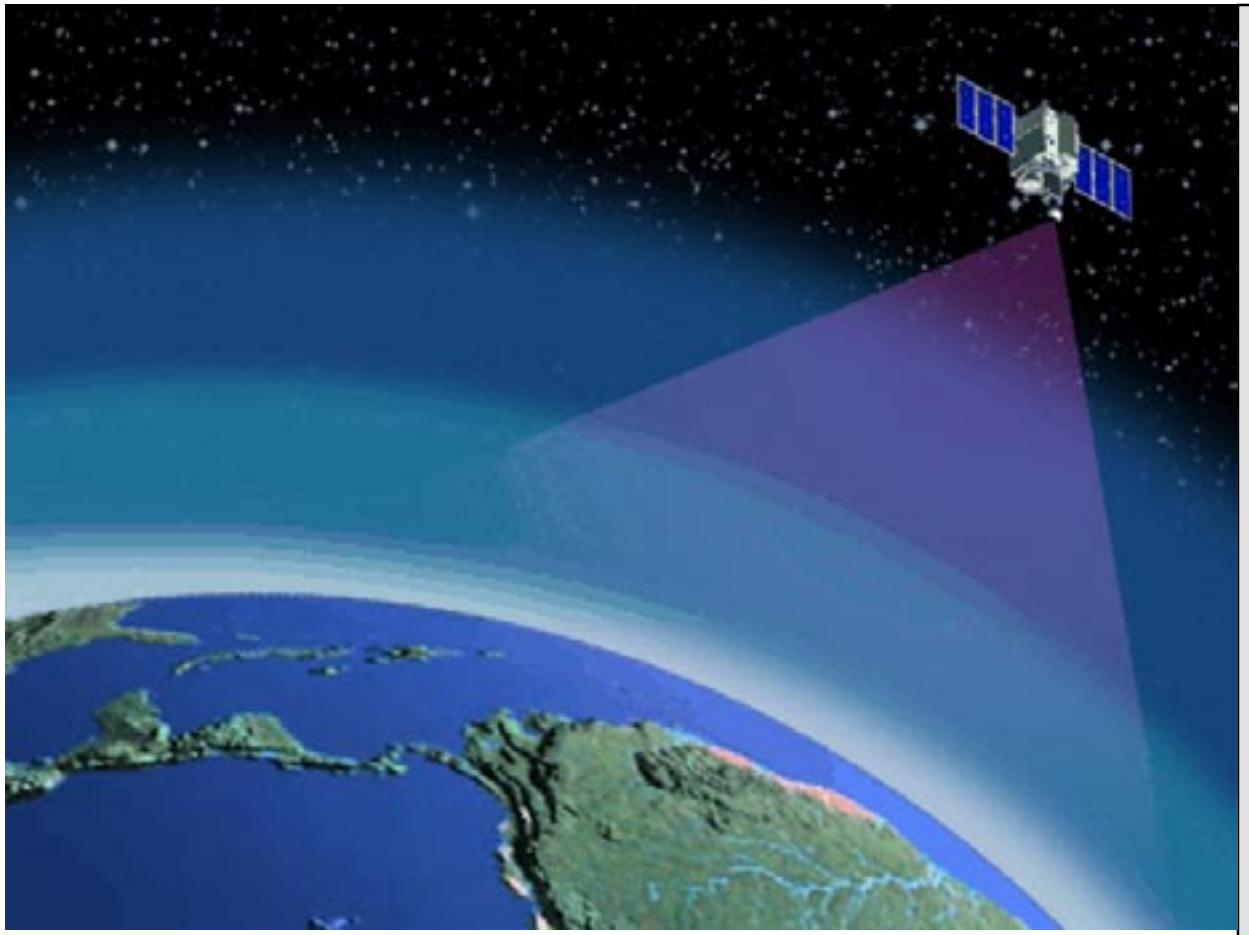
Fourier Transform Spectrometer (FTS) Provides Simultaneous Measurement of the Vertical Dimension

Vertical Sounding Technique

Wavelength Converts to Altitude



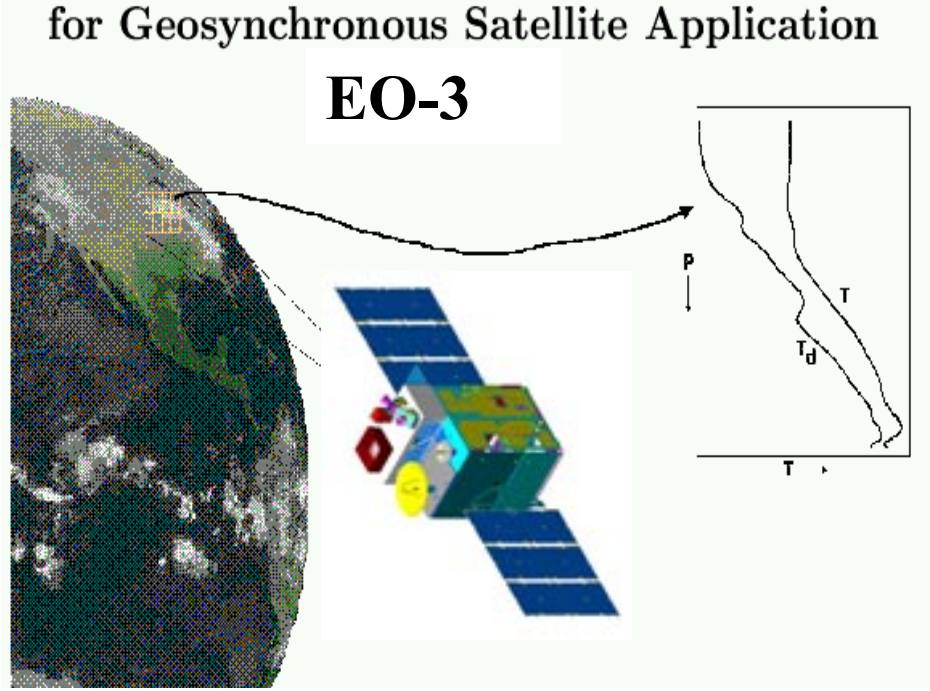
GIFTS Sampling Characteristics



- Two 128x 128 Infrared focal plane detector arrays with 4 km footprint size
- One 512 x 512 Visible focal plane detector array with 1 km footprint size
- Field of Regard 512 km x 512 km at satellite sub-point
- Ten second full spectral resolution integration time pe Field of Regard

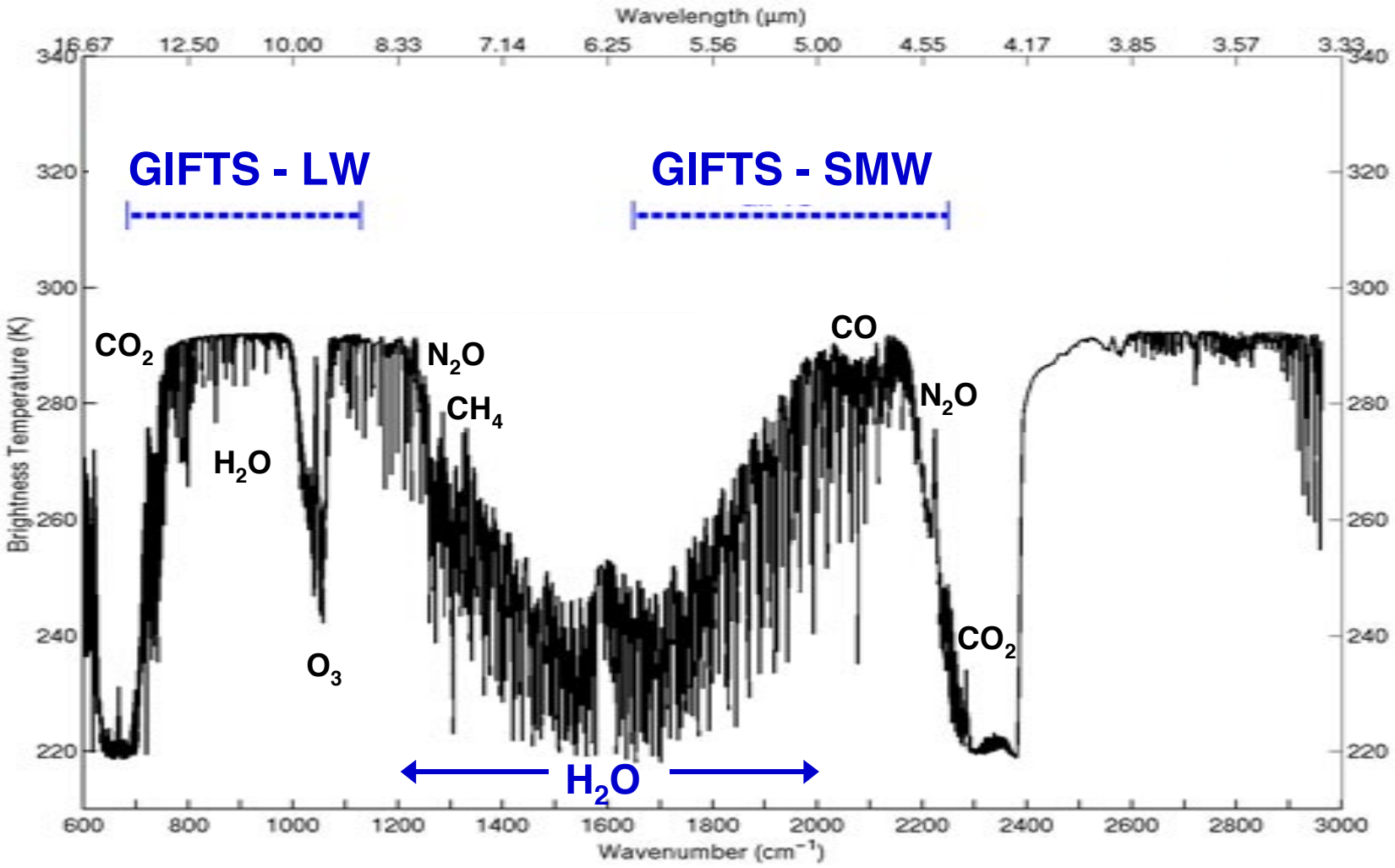
GIFTS Upper Air Observation Density

Global Conventional Balloon Systems provide ~1000/day widely separated vertical soundings over land areas



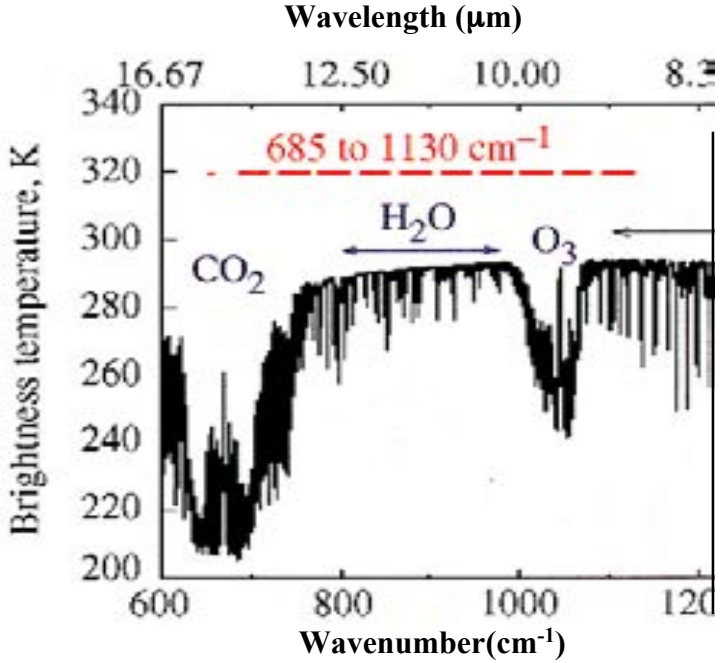
GIFTS will provide ~ 100,000/min closely spaced vertical temperature & moisture soundings over land and sea!

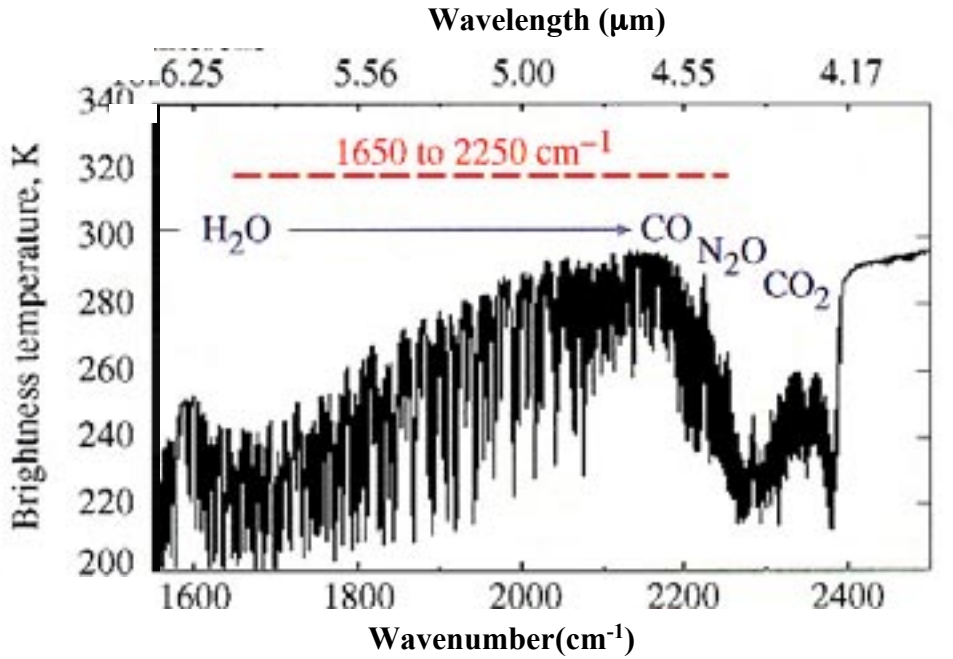
Spectral Coverage



Spectral Coverage is Optimized for Multi Spectral Imagery Applications and Temperature and Water Vapor Sounding

IR Measurement Objective





Longwave IR Focal Plane:

(8.8 to 14.6 microns)

- **Temperature sounding**
- **Ozone profiling**
- **Cloud altitude**
- **Surface temperature**
- **"Invisible" cirrus cloud detection**
- **Dust/Aerosol optical depth**

Shortwave IR Focal Plane:

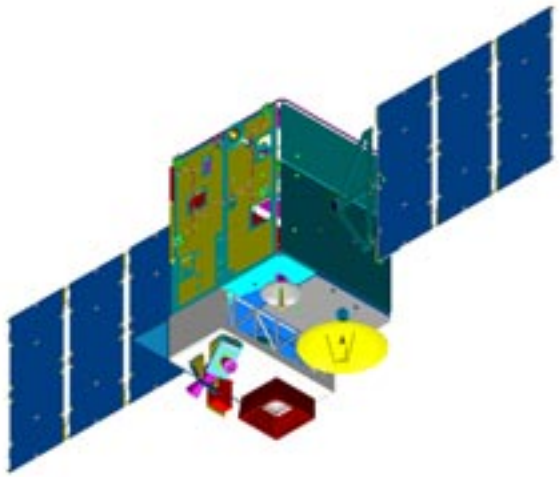
(4.4 to 6.1 microns)

- **Water vapor sounding**
- **Carbon Monoxide profiling**
- **Boundary layer temperature sounding**
- **Surface temperature**
- **Stratus cloud detection**

GIFTS Measurement Objectives

Key Technologies

- *Fourier Transform Spectrometer*
- *Large area format focal plane array*
- *Advanced data readout and digital signal processing electronics*
- *Redundant low mass low power cryogenic coolers*



Operational Constraints

- *Launch date: Fall 2005 to geosynchronous orbit*
- *Operational life: 1 yr NMP/NOAA, 5 yr Navy*
- *Resources: Mass <130 kg, Power<420 w, Data Rate <65 Mbit/sec*

Measurement Capability

- *Measure temperature, water vapor, tracer wind, and chemical composition distribution with high spatial and temporal resolution to enable revolutionary improvements in operational weather observation, prediction and air quality monitoring.*
- *Provide dynamic observations of cloud spectral radiance and associated atmospheric properties.*
- *Observe the transport of radiatively active pollutants and greenhouse gases.*

GIFTS Technology Validation Objectives

TO1. Imaging Interferometer
- Demonstrate a cryogenic Michelson interferometer optimized for sounding applications.

TO2. LFPA and Advanced Cryogenic Cooling
- Demonstrate large area detector arrays and readouts and associated miniaturized cryocoolers.

TO3. High Speed Signal Processing
- Demonstrate high-speed, ultra-low-power signal processing.

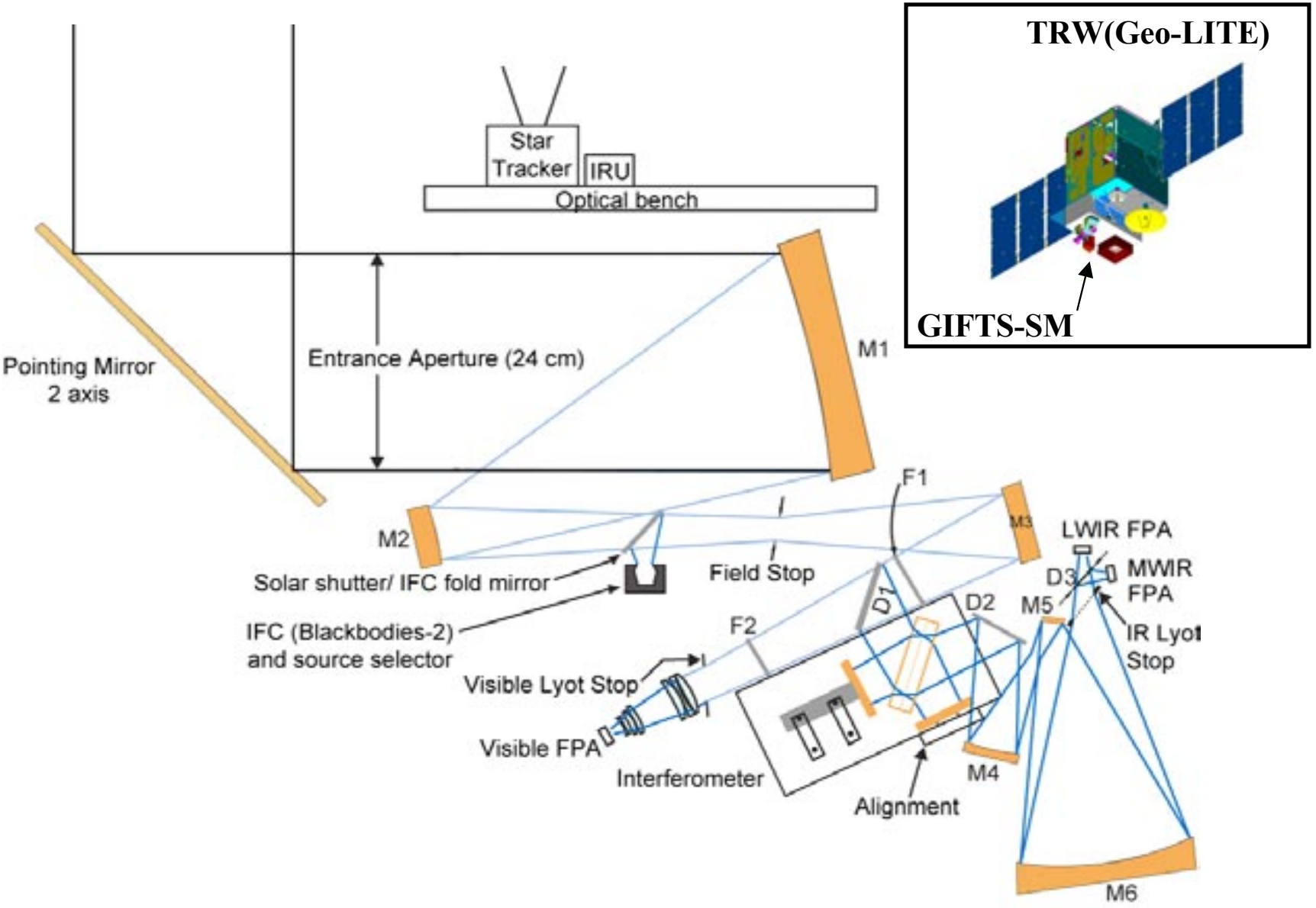
TO4. Data Compression
- Demonstrate on-board real-time signal processing and data compression.

TO5. Autonomous Pointing and Control
- Demonstrate autonomous pointing and control systems for precise image stabilization and feature tracking.

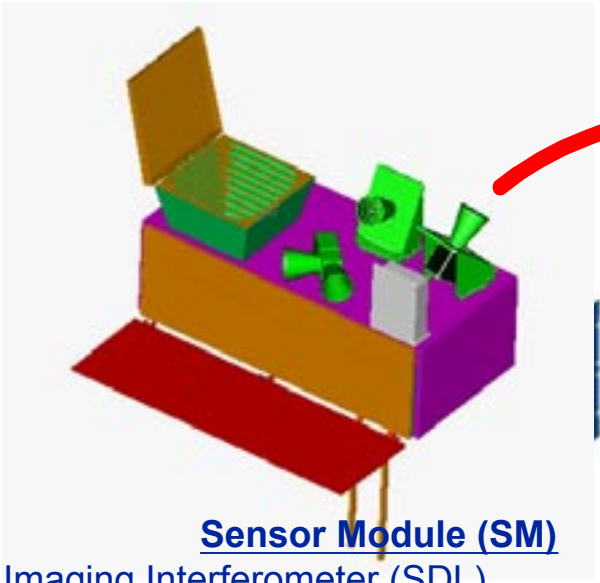
TO6. Low Power Radiation Tolerant Microelectronics
- Demonstrate radiation protection and ultra-low-power electronics.

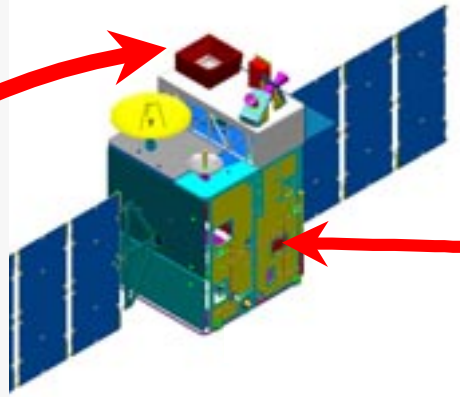
TO7. Lightweight Structures and Optics
- Demonstrate lightweight optics and structures to minimize instrument mass.

GIFTS Sensor Module Design



GIFTS Technologies





Sensor Module (SM)

TO1: Imaging Interferometer (SDL)
- Cryogenic Michelson Inteferometer
- Laser Metrology System
- Calibration

TO2: 128 x 128 IR FPA (BAE)
TO2: Cryo-Cooler (TRW)
TO3: Rad-Hard Analog to Digital Converters (Raytheon)
TO3: Hi-speed Digital Filter/Co-adder (SDL)
TO5: Autonomous Pointing & Control
- Pointing Mirror Assembly (PMA) (SSG)
- Star Tracker (T A&M)
- 512 x 512 Visible FPA (JPL)

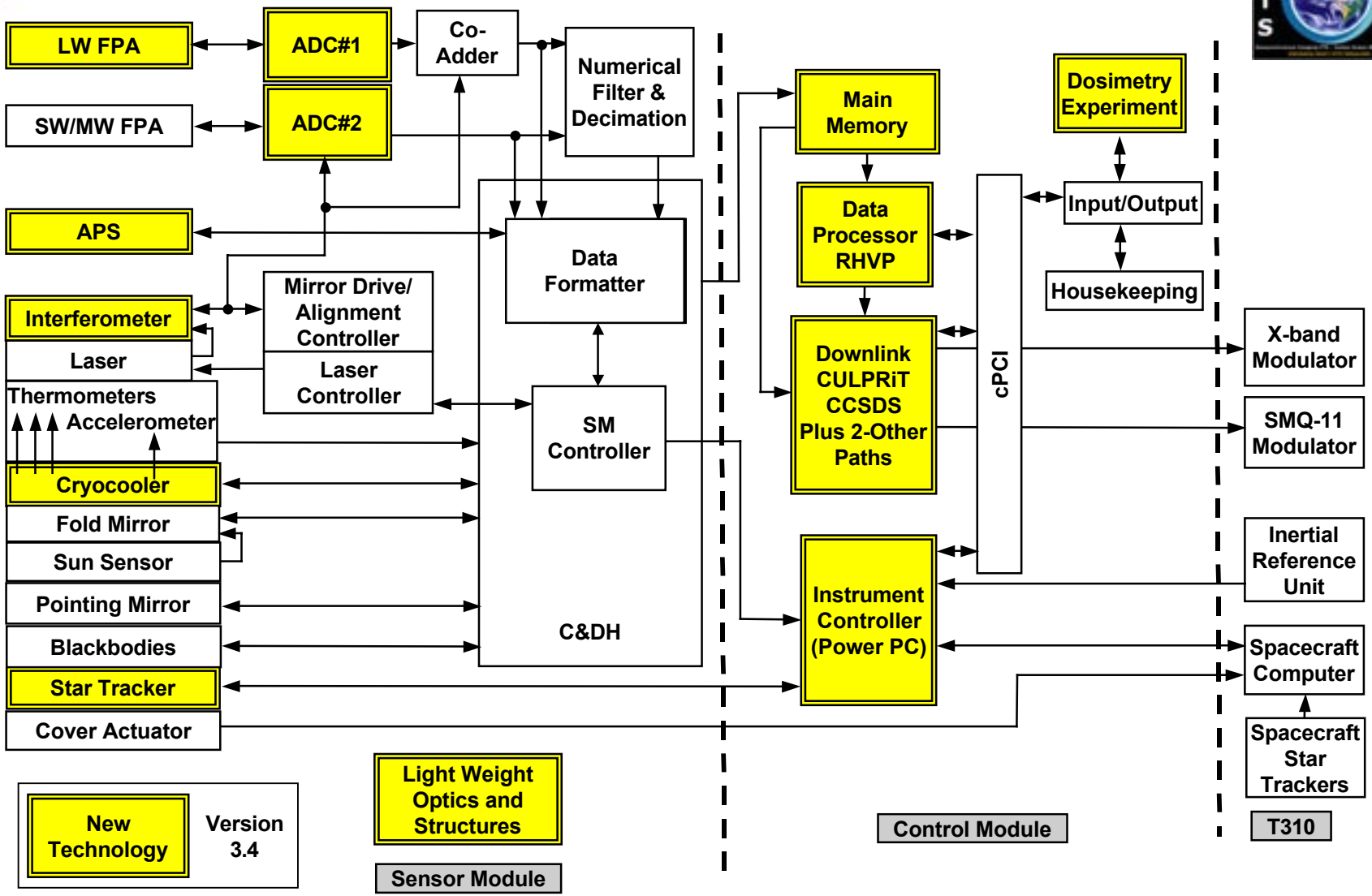
TO7: SiC Telescope (SSG)

Control Module (CM)

TO3: PowerPC Rad750 (BAE)
TO3: Neo-Stack Memory (1GB) (ASRC/Irvine Sensors)
TO4: Data Compression Experiment
- Rad-Hard Vector Processor (Honeywell)

TO6: CULPRiT CCSDS Downlink (UNM)
TO6: Radiation Dosimetry Experiment
- Shaped Sheilding (LaRC)
- Thermal Spray (Honeywell)
- Composite Equipment Enclosure (COI)

EO3 GIFTS Technologies for Validation



Validating technology at the system-level is challenging because some technologies are embedded and requires extensive operations and instrumentation planning for their validation.

Technology Status Summary

	TRL	Technical			Schedule			Cost		
		Aug	Sep	Oct	Aug	Sep	Oct	Aug	Sep	Oct
Imaging Interferometer	5	G	G	G	G	G	G	G	G	G
Focal Plane Array	5	Y	Y	Y	G	Y	Y	G	G	G
Cryocooler	5	Y	Y	Y	Y	Y	Y	G	G	G
Rad-Hard Vector Processor	5	G	G	G	G	G	G	G	G	G
A/D Converter	5	G	G	G	G	G	G	G	G	G
Power PC	5	G	G	G	G	G	G	G	G	G
CULPRiT	4-5	G	Y	Y	G	G	G	G	G	G
Composite Optics	5	G	G	G	G	G	G	G	G	G
Stacked Memory	5	G	G	G	G	G	G	G	G	G
Radiation Protection	5	G	G	G	G	G	G	G	G	G
Advanced Pixel Sensor	5	G	G	G	G	G	G	G	G	G
Star Tracker	4	G	G	G	G	G	G	G	G	G

Technology Status Summary

- GIFTS Technology Readiness:
  - 10 out of 12 technologies technologies are currently at TRL 5
  - CULPRiT will reach TRL 5 by 3/02
  - Star tracker will reach TRL 5 by 6/02
  - All technologies will reach TRL 6 after completing instrument testing
- Guideline to deliver technologies (to SM & CM):
  - Approx $10M actual expenditures to date
  - Approx $43M estimated at completion

Mission Description

- GIFTS-IOMI is mission being conducted jointly by NASA, the Department of Navy (DON) Office of Naval Research (ONR), and NOAA.
- NASA Earth Observing-3 (EO-3)
  - EO-3, a mission in NASA's New Millennium Program (NMP) validates breakthrough technologies, and next generation measurement concepts
  - The GIFTS instrument provides unprecedented spatial and temporal weather soundings
- Indian Ocean METOC Imager (IOMI)
  - Uses the GIFTS instrument for a demonstration of operational utility.
  - Provides meteorological products directly to shipboard and shore assets in and around the Indian Ocean
- Two operational phases (EO-3 & IOMI)
- NOAA will support EO-3 Phase with a dedicated X-Band ground station.
- NOAA will enhance the utility of GIFTS through a NOAA-funded and executed Product Assessment Program.

GIFTS/IOMI Proposed Operational Concept

GIFTS/IOMI Enables Improved Global Weather Prediction

Opportunity for Inter-Agency And International Cooperation

Mission Architecture

Space Segment
- Spacecraft
  - Control satellite
  - Support data collection
  - Provide communications
  - Thermal and electrical power
  - Provide failsafe protection
- GIFTS Instrument
  - Control satellite
  - Support data collection
  - Provide communications
  - Thermal and electrical power
  - Provide failsafe protection
- Provide test support

Launch Segment
- Launch vehicle
- Launch support equipment
- Launch facilities

Mission Operations Segment
- Manage Mission Operations
  - Plan integrated mission events
  - Plan satellite operations
  - Plan payload operations
- Coordinate Observation Requests

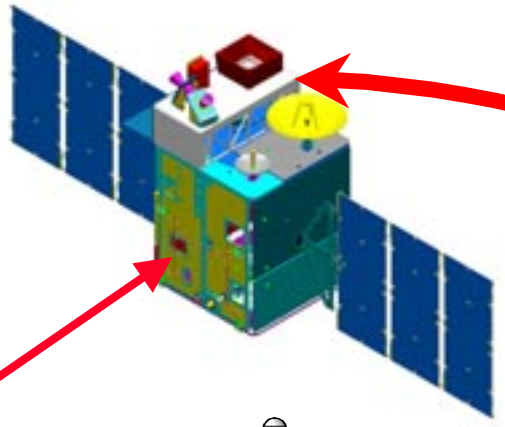
Ground Systems Segment

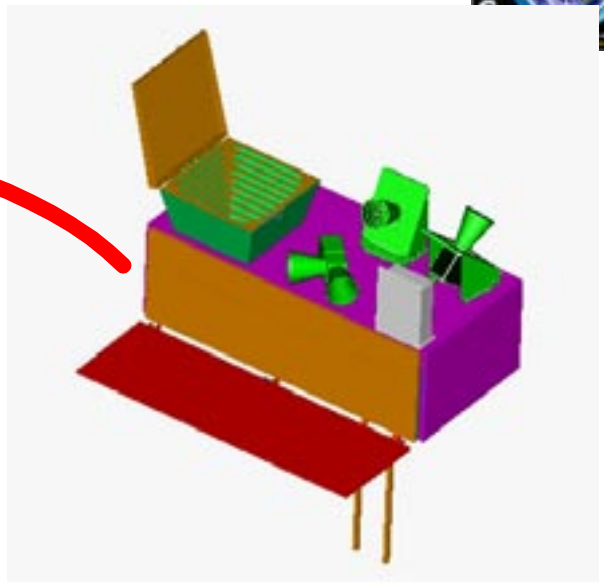
Satellite Systems Control System	Payload Operations Control Sys	Data Processing System
•Build command sequences •Perform engineering and analysis •Monitor and analyze health and safety •Analyze flight dynamics •Maintain satellite database •Prepare and send satellite commands •Maintain satellite flight software •Route mission data	• Ingest and validate RDRs • Build payload commands • Process RDRs to Level 1 • Route RDRs and Level 1 products to DAAC • Monitor and analyze payload health and status	•Generate measurement concept validation products •Generate technology validation products •Perform calibration processing •Ingest Level 1 data from DAAC •Provide data products to DAAC

Ground Systems ICD
- Defines interface between all GSS elements
- Defines interface to external systems

Space & Launch Segment Elements

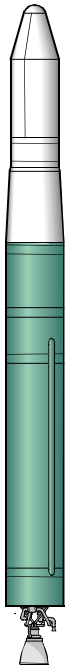
Spacecraft
TRW T-310





Control Module (CM)
PowerPC (Rad750)
Downlink I/O
Vector processor
Memory and SM I/O
Radiation Dosimetry board (1)

Delta-4 Launch Vehicle

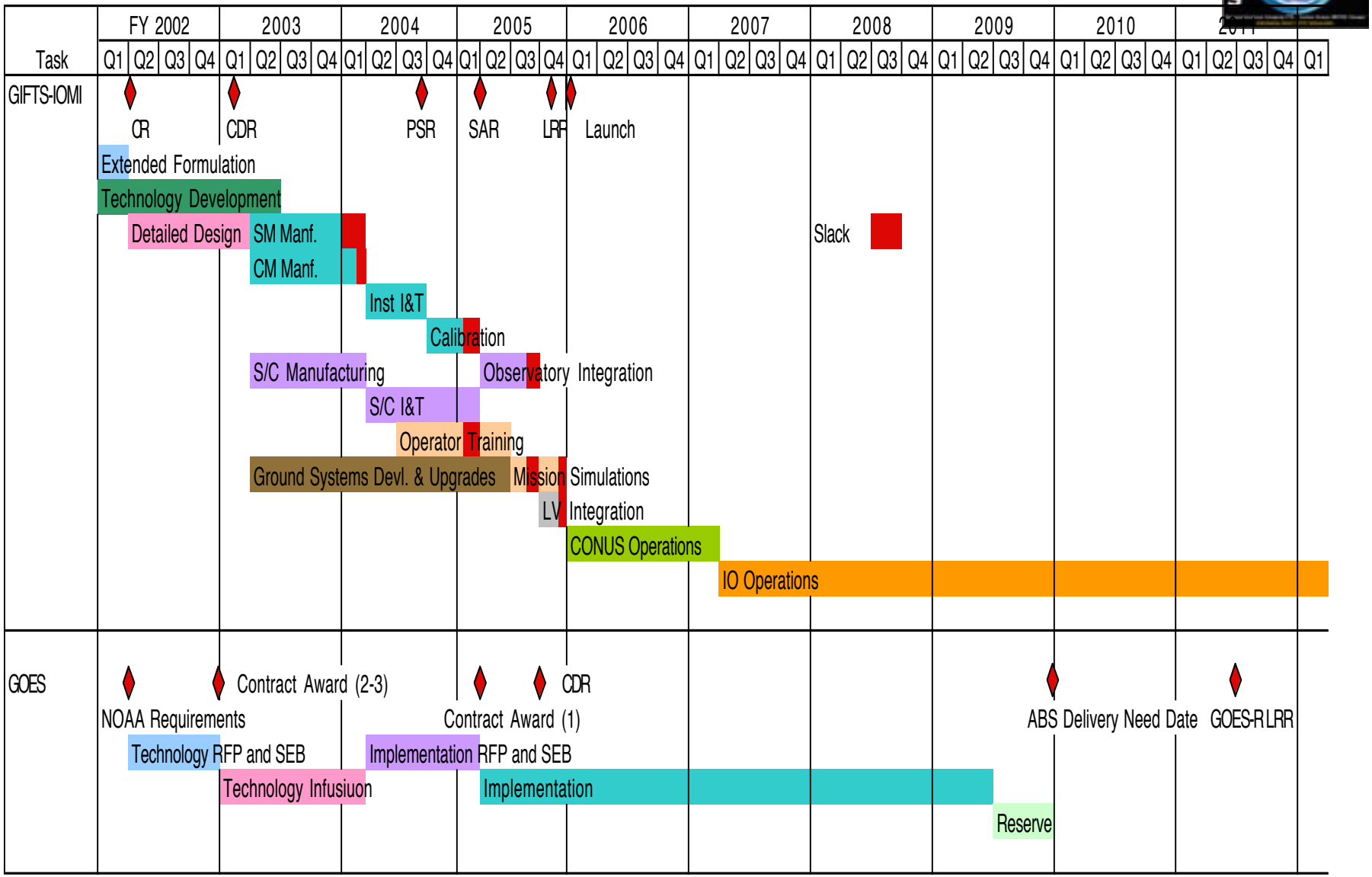


Sensor Module (SM)
Imaging Interferometer
- 128 x 128 IR FPA (2)
- 512 x 512 Visible FPAs
- 7 selectable resolutions (36-0.6 cm $^{-1}$)

Cryo-Cooler
Closed-loop Point and Control
- Gimbal, Star Tracker, Gyro

Calibration Sources
Metrology System

Top Level Mission Schedule



Current Mission Status

- System Requirements Review completed July 18, 2000.
- Preliminary Design Review completed March 20-22, 2001.
  - 26 Actions assigned
- 2 Independent cost estimates performed
  - Aerospace Corp., NASA Independent Program Assessment Office
  - Both validated GIFTS-IOMI project estimates
- Project directed to focus on technology maturation and instrument risk reduction activities while awaiting confirmation
  - NASA provided $7M to support these activities
  - Mission development activities minimized
  - Comprehensive Technology Validation Planning Meeting conducted 10/24
- NOAA has adopted the GIFTS baseline for the Advanced Baseline Sounder (next generation GOES sounder)
- ATP into implementation is expected in Jan. 2002.